Attachment 4. Project Description for "Sacramento Valley Basin/Solano Subbasin Groundwater-Surface Water Flow Model to Evaluate Recharge and Conjunctive Water Use"

Project Purpose and Goals

In 2005, SCWA prepared an Integrated Regional Water Management Plan (IRWMP) on behalf of itself and its member agencies, including all the agencies overlying the Solano Subbasin. The IRWMP identified "increased Use of Groundwater" and "Increase Opportunities for Conjunctive Use" as Tier 1 (the highest) priorities. Entities within the county that rely on groundwater for all or a portion of their supply include the cities of Vacaville, Rio Vista, and Dixon and water districts such as Rural North Vacaville Water District (RNVWD) and Solano Irrigation District (SID). Additional groundwater development is planned in other areas as a means of increasing water supply availability and reliability. The IRWMP recognizes that groundwater in Solano County is underutilized; however, more information is needed to determine where and to what extent greater utilization is possible. Correspondingly, additional information and analyses are required to evaluate the availability of groundwater in conjunction with surface water to meet future water requirements.

One of the goals of this project, through the development of the groundwater – surface water flow model, is to consider the potential effects of conjunctive water use scenarios on stakeholders in the greater Solano area, including the Sacramento River and other significant surface water courses in the model area. Agencies such as DWR and the USBR would be especially interested in the quantification of the potential for streamflow depletion of such surface water courses in response to conjunctive use of groundwater in the model area.

Another goal of this project is to evaluate the effects of developing new and/or redistributing deep pumpage either horizontally over a spatial area or vertically over different aquifer units with the goal of reducing drawdowns in the basal zone. This task directly relates to improving the understanding of the relationship between pumping effects and maintaining desired groundwater levels (i.e., levels that do not show continued decline and/or would not contribute to significant inelastic subsidence) by focusing on the basal zone as an important aquifer unit for public water supply (existing and for potential future development).

Recent Related Studies

SCWA has conducted two studies that "Northern Solano County Groundwater Monitoring Program" (begun in 2006) and the "AB 303 Solano Groundwater Investigations Project" that provide the physical conceptual foundation necessary for the development of the groundwater-surface water flow model proposed in this LGA grant application.

Northern Solano County Groundwater Monitoring Program

The 2005 IRWMP acknowledged that additional data about the groundwater basin was needed to implement the recommendations in that plan. As recommended by the IRWMP, and consistent with the GWMP's of SCWA's member entities, SCWA funded the installation of four deep (over 2000 feet) nested monitoring wells and two subsidence monitoring stations in the Solano Subbasin. Costs, including engineering, construction, data analysis and reporting, was over $2 million funded by SCWA. The data collected significantly increase the knowledge about the geology of the groundwater basin and provide more information to current groundwater users and provide information leading to conjunctive use projects.

One of the objectives for the new SCWA monitoring sites was to expand groundwater level data for the basal zone and overlying zones of the Tehama Formation to assess the extent of effects of basal zone pumping. Levels measured at the new SCWA monitoring sites indicate that basal zone pumping has a wider effect than previously recognized. Continued groundwater monitoring will confirm this response to basal zone pumping, although the effect is not unexpected due to the highly confined nature of this deeper part of the aquifer system. Increased groundwater extraction in the basal Tehama Formation will continue to lower groundwater levels. Levels are also likely to decrease below historic levels, especially in areas where there has been little to no prior development of groundwater supplies from the basal Tehama Formation. Groundwater levels may reach a new equilibrium between extraction and recharge or, at some stage of total groundwater level development from this deep unit, would continue to decline reflecting a net deficit in the overall groundwater budget.

As part of SCWA's "Northern Solano County Groundwater Monitoring Program", two continuously operating references (CORS) stations were installed in May 2012 in the project study area to monitor changes in land surface elevation at each respective site. Each CORS station will record vertical and horizontal land surface movement utilizing global positioning technology. The elevation data collected at each station, data from existing CORS stations, and data from traditional surveys will be used along with water level data collected from wells in the monitoring program and pumpage data from area wells to determine if a correlation exists between groundwater levels and ground surface elevation changes. These data will be used along with the GSFLOW model for the ultimate goal of developing groundwater resource utilization strategies that minimize land subsidence.

AB 303 Solano Groundwater Investigations Project

As part of the "AB 303 Solano Groundwater Investigations Project" conducted by SCWA in coordination with others, Component 1 of the project was on hydrogeologic interpretation of the deep aquifer system in northern Solano County. The primary goal of Component 1 was to develop a fundamental understanding of the basal Tehama and other deep aquifer formations and their relationship with overlying units. Findings of the project included:

- The basal Tehama Formation is highly confined and groundwater levels appear to be affected at significant distances (e.g., beyond 5 miles) from where groundwater is pumped from this unit;
- Although the Tehama Formation outcrop area north of Vacaville is relatively extensive, the upper part of the Tehama Formation is dominated by lower permeability materials that likely reduce recharge to the basal unit;
- The depth of the basal unit of the Tehama Formation and the lower permeability of overlying materials hinders vertical recharge;
- Some leakage through overlying confining units may occur, however, this should be further evaluated;
- Groundwater released from storage in confining units may be a more significant source of short-term recharge to the basal unit than leakage through these units; and
- Groundwater level data and trends examined for the period from 2002 to about 2008 suggested that full spring groundwater level recovery was generally not occurring. Although this is a short observation period, this response, combined with the extended cone of depression in the northern Solano area, indicates that the flow occurring in the direction of the cone had not yet stabilized to equal groundwater discharge from that area.
- Observations also suggested that groundwater recharge sources are limited and may be further constrained. When groundwater released from storage in confining beds is no longer recoverable, it no longer serves as a source of recharge.

The above observations from the "AB 303 Solano Groundwater Investigations Project" further suggested that groundwater recharge sources are limited and may be further constrained. It is planned that groundwater can be utilized to a greater extent in the Solano Subbasin. However, more information is needed to determine where and to what extent greater utilization is possible. Given the above conditions, the potential subsidence is also a very important consideration.

Additional Related Work

Other work authorized by SCWA and underway in 2011 includes: 1) Expanding SCWA's current database with aquifer zone-specific well construction detail, and 2) Additional geologic studies, which included the extension of two of the geologic cross sections in the northern Solano County area and completion of structure contours and isopach maps of the basal zone of the Tehama Formation to near the Sacramento River. Furthermore, these two tasks were implemented for the purpose of improving the understanding of the relationship between water levels of different zones in the subsurface of the Northern Solano Subbasin, allowing for the interpretation of vertical gradients, communication between zones, and potential recharge sources. The second task described above was in support of the development of a physical

model of the subsurface that may be readily incorporated in a numerical groundwater flow model.

Previously, a model (the Integrated Water Flow Model [IWFM]) had been developed for the larger Solano vicinity; however, that model was limited to a single layer representing the upper part of the aquifer system. The prior model did not include any of the pumping stresses occurring on the aquifer system beneath a depth of about 600 feet, i.e., no pumping from wells completed in the basal zone of the Tehama Formation was included. The prior model also included just one stream (lower reach of Ulatis Creek and Cache Slough) in the area modeled at that time.

California Statewide Groundwater Elevation Monitoring Program

In November 2009, Senate Bill SBX7-6 mandated that the groundwater elevations in all basins and subbasins in California be regularly and systematically monitored with the goal of demonstrating seasonal and long-term trends in groundwater elevations. In accordance with the mandate, DWR developed the California Statewide Groundwater elevation Monitoring program (CASGEM).

In December 2010, SCWA applied to DWR to become the local, essentially countywide, Monitoring Entity responsible for designating wells as appropriate for monitoring and reporting groundwater elevations for purposes of the CASGEM program. The wells selected by SCWA for this program are a subset of the overall wells monitored in the countywide monitoring network. The other pre-existing countywide groundwater monitoring has been occurring in Solano County for some time, in some cases decades.

SCWA, as the Monitoring Entity, proceeded to identify a subset of monitored wells to be included in the CASGEM network and to prepare a CASGEM Network Plan as required by DWR. In December 2011, when SCWA's CASGEM Network Plan was submitted to DWR, 49 wells were included in the program.

Development and Utilization of USGS Groundwater-Surface Water Flow Model

The work for this LGA Grant Application involves the development and utilization of a numerical flow model called GSFLOW to simulate surface water and groundwater movement in the Solano County area. The purpose of creating this model is to provide a tool for decision-makers and groundwater suppliers with the ability to analyze effects of groundwater management and pumpage regimes within the context of surface water groundwater interaction and the complexity of the subsurface and various water-bearing aquifer units used for public supply. The GSFLOW platform refers to the U.S. Geological Survey's publicly available tested and established numerical Groundwater and Surface Water Flow (GSFLOW) Model based on the integration of two widely used modules namely the Precipitation-Runoff Modeling System (PRMS) and the Modular Groundwater Flow Model (MODFLOW-2005). This coupled integrated hydrologic model was chosen because not only is it in the public domain (which aids in its sharability), it is useful for analyzing complex water-resources problems that consider

feedback processes that affect the timing and rates of evapotranspiration, surface runoff, soil-zone flow, and groundwater interactions.

The numerical groundwater flow model has potential applicability for addressing questions posed by DWR and the USBR relating to the influence of pumping on streamflow, particularly concerning wells located near to the Sacramento River. Additionally, as part of previous work done for the County (LSCE, 2010), it was recommended that a groundwater flow model be developed that was capable of evaluating the response of the entire complex aquifer system (including the basal zone of the Tehama Formation) in order to analyze different surface water and groundwater management scenarios. The more complete model would be used to:

- Simulate the results of conjunctive use activities such as increased groundwater pumping (upper and lower portions of the aquifer system) during dry years and reduced pumping during wet years;
- Simulate the effects of redistributing pumpage either horizontally or vertically to reduce drawdowns in the basal aquifer zone;
- Examine recharge and interconnectivity to the lower freshwater bearing zones;
- Examine the implications of lowered groundwater levels and potential subsidence;
- Determine the groundwater budget for the complex aquifer system such as exists in the greater Solano area;
- Address questions concerning long-term reliability of supply from the deeper freshwater-bearing units in the northern Solano County area; and
- Examine whether pumping from planned conjunctive use activities have an effect on surface water flows (i.e., streamflow depletion in the Sacramento River).

The model area will preliminarily cover the area between the following boundaries:

- Northern Boundary: Approximately one mile north of Putah Creek
- Eastern to Southern Boundary: Approximately one mile east of the Sacramento River to south of Rio Vista to the boundary between the Solano Subbasin and the Suisun-Fairfield Valley Basin.
- Western Boundary: The western model boundary would follow the Solano County western boundary to just north of Fairfield then the model boundary would follow the boundary between the Suisun-Fairfield Valley Basin and the Solano Subbasin.

The model area is proposed to extend beyond Putah Creek and the Sacramento River to allow for evaluation of surface water/groundwater interaction, particularly whether or not streamflow depletion would occur due to planned conjunctive use activities.

The model platform planned to be used is a publicly available coupled groundwater and surface water flow model (GSFLOW) by the US Geological Survey. The model integrates two USGS

modeling applications, including the USGS' Precipitation-Runoff Modeling System and the USGS Modular Groundwater Flow Model (MODFLOW-2005). GSFLOW was developed by the USGS to simulate coupled groundwater/surface-water flow in one or more watersheds by simultaneously simulating flow across the land surface, within subsurface saturated and unsaturated materials, and within streams and lakes. Important inputs consist of climate data such as measured or estimated precipitation, air temperature, and solar radiation. Other key input data include groundwater stresses (such as withdrawals) and model boundary conditions. The model incorporates well documented methods for simulating runoff and infiltration from precipitation; balancing energy and mass budgets of the plant canopy and soil zone; and simulating the interaction of surface water with groundwater. The USGS reports that an important aspect of GSFLOW is its ability to conserve water mass and to provide comprehensive water budgets. The quality and usefulness of the model results will be measured by the success of the calibration of the model, and the applicability of the model scenarios to management practices involving groundwater pumpage amounts and conjunctive use operations.
Most importantly, use of the GSFLOW model will aid evaluation of recharge in relation to pumpage as further described below.

Groundwater Recharge and California Water Code 10753.7 (AB 359)

The water budget output from the GSFLOW model is also important with respect to quantifying groundwater recharge in the model area.

In 2011, AB 359, the Assembly Bill by Assemblyman Huffman that adds mapping of groundwater recharge to the California Water Code (CWC 10753.7(3) and (4)(A) and (D)) was adopted and becomes effective January 1, 2013. The new language in CWC 10753.7(3), (4)(A), and (4)(D) is included below:

> (3) For purposes of implementing paragraph (1), the local agency shall prepare a map that details the area of the groundwater basin, as defined in the department's Bulletin No. 118, and the area of the local agency, that will be subject to the plan, as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan.
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> (4)(A) Commencing January 1, 2013, for purposes of implementing paragraph (1), the groundwater management plan shall include a map identifying the recharge areas for the groundwater basin.
> (4)(D) For purposes of this paragraph, "map identifying the recharge areas" means a map that identifies, or maps that identify, the current recharge areas that substantially contribute to the replenishment of the groundwater basin.

SCWA would use the GSFLOW model to develop the recharge area mapping information that will be needed by all SCWA's member entities (including the City of Vacaville, RD 2068, and

SID) that will need to add this information to their respective groundwater management plans (GWMPs) to bring the plans up to date with the new California Water Code requirements.

Supporting Groundwater Management Plans' Goals and Objectives

In addition to providing information on recharge areas, the implementation of a numerical flow model will support the goals and objectives of SCWA's member entities' GWMPs. For example, the City of Vacaville's 2011 Groundwater Management Plan Update includes groundwater management component 2: water resource sustainability, of which determination of sustainable pumpage, continuation of conjunctive use operations, and water conservation are all pieces. The numerical model will directly address pumpage amounts in different aquifer units, as well as the various conjunctive use operations being considered. Another component in this GWMP involves identification and management of recharge areas and wellhead protection areas, of which the numerical flow model will support using its water budget output. One of RD 2068's GWMP objectives includes groundwater/surface water interaction, of which the proposed numerical model will support to a much higher degree than the IWFM model by utilizing the sophisticated precipitation runoff module coupled with the groundwater flow module.

Collaboration with Other Local Public Agencies and Outreach

SCWA plans to collaborate with other local public agencies (including its member entities from Benicia, Dixon, Fairfield, Maine Prairie Water District, RD 2068, Rio Vista, Solano County, Suisun City, Vacaville, and Vallejo) in the data gathering process. The agency will hold regularly scheduled meetings with technical staff from each member entity in order to disseminate relevant data and to ensure the project objectives are being met. Member agencies using groundwater will continue to report their groundwater levels to DWR. SCWA will be reporting groundwater data from the new SCWA monitoring wells to DWR.

SCWA will hold a kick-off meeting with both urban and agricultural retailing agencies. The purpose of this kick-off meeting is to coordinate the preparation of the groundwater model and to ensure each agency is aware of the goals and objectives of the project. Additionally, the water agency Board of Directors will receive project updates at their monthly public meetings.

Ongoing Use of the Numerical Flow Model

The numerical flow model is planned to be fully operational and complete with the grant funds and does not anticipate needing additional funding after grant funds are expended. As management practices have the potential to change, the numerical model offers a platform for analyzing consequences of potential changes, as well as interpreting changes in climatic conditions. The numerical flow model provides the tool for further scenario development for conjunctive use operations and different pumping regimes yet to be developed. As such, SCWA may choose to fund future projects involving the use of this sophisticated groundwater tool.